High Temple Workshop 24
2-5 February 2004
Sacramento, California

New Material Transition From an OEM Perspective

Content related to Accelerated Insertion of Materials – Composites (AIM-C) which is jointly accomplished by a Boeing Led Team and the U.S. Government under the guidance of NAVAIR. Work funded by DARPA/DSO (Dr. Leo Christodoulou) and administered by NAVAIR through TIA N00421-01-3-0098.

John M. Griffith

Technical Fellow
Phantom Works
The Boeing Company
St. Louis, Missouri

(314) 234-5968

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2004	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
New Material Transition From an OEM Perspective	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **The Boeing Company St. Louis, Missouri**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**15**	

Agenda

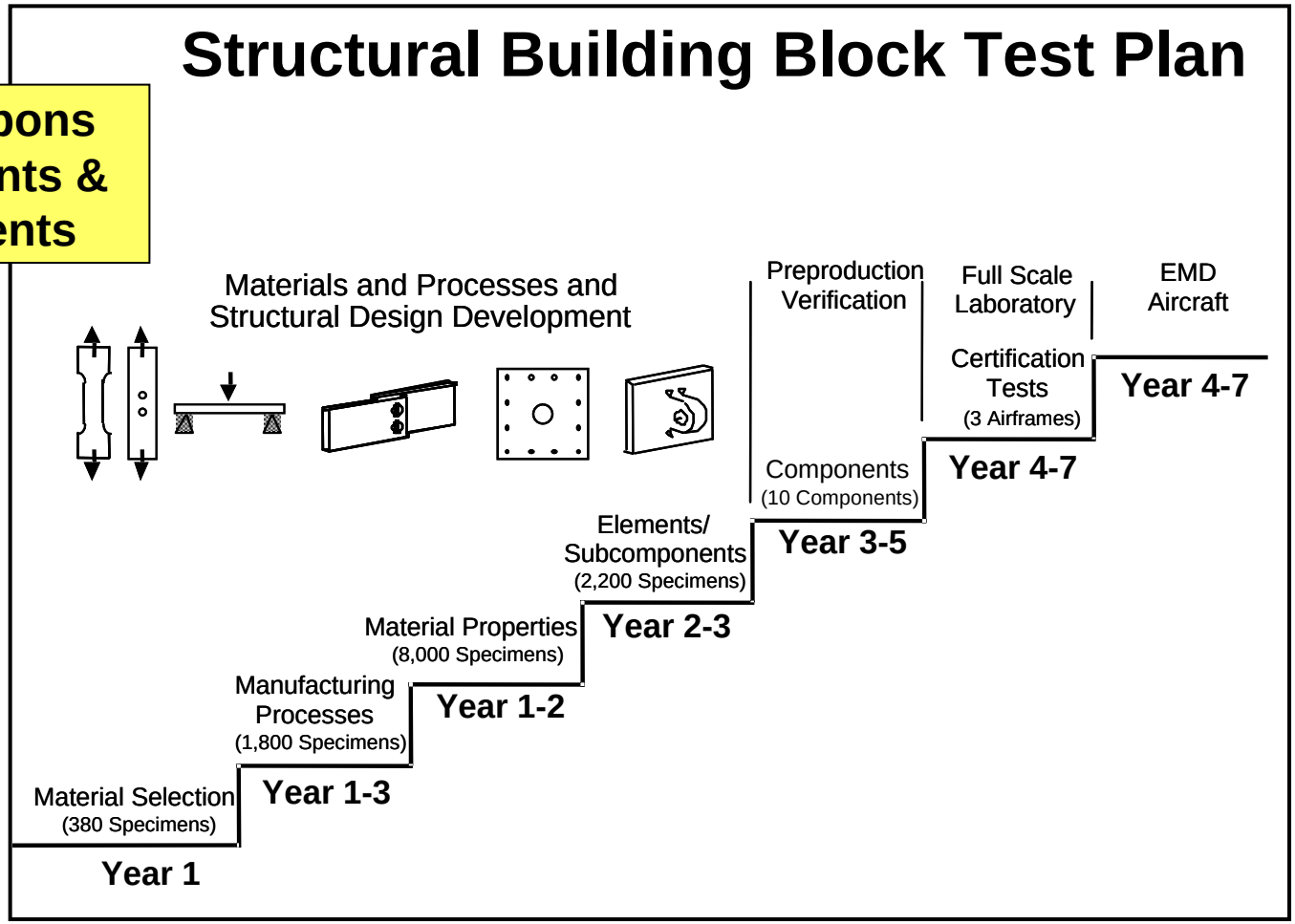
In the composites industry, there is significant, widespread confusion and frustration relating to material transition onto products. This presentation goes into several areas pertaining to an increased understanding from a multiple discipline perspective.

- **Background**
- **Maturity**
- **Disciplines**
- **Conformance**
- **Summary**

Background

Transition means putting it onto an application…

- **>10,000 Coupons**
- **>2000 Elements & Subcomponents**



…Application Acceptance is Through Certification With Stepwise Risk Reduction

Background

Designer Data/Information Needs for Application Certification

Structural

- Strength and Stiffness
- Weight
- Service Environment
  - Temperature
  - Moisture
  - Acoustic
  - Chemical
- Fatigue and Corrosion Resistant
- Loads & Allowables

Manufacturing

- Recurring Cost, Cycle Time, and Quality
- Use Common Mfg. Equipment and Tooling
- Process Control
- Inspectable
- Machinable
- Automatable
- Impact on Assembly

Supportability

- O&S Cost and Readiness
- Damage Tolerance
- Inspectable on Aircraft
- Repairable
- Maintainable
  - Accessibility
  - Depaint/Repaint
  - Reseal
  - Corrosion Removal
- Logistical Impact

Material & Processes

- Development Cost
- Feasible Processing Temperature and Pressure
- Process Limitations
- Safety/Environmental Impact
- Useful Product Forms
- Raw Material Cost
- Availability
- Consistency

Miscellaneous

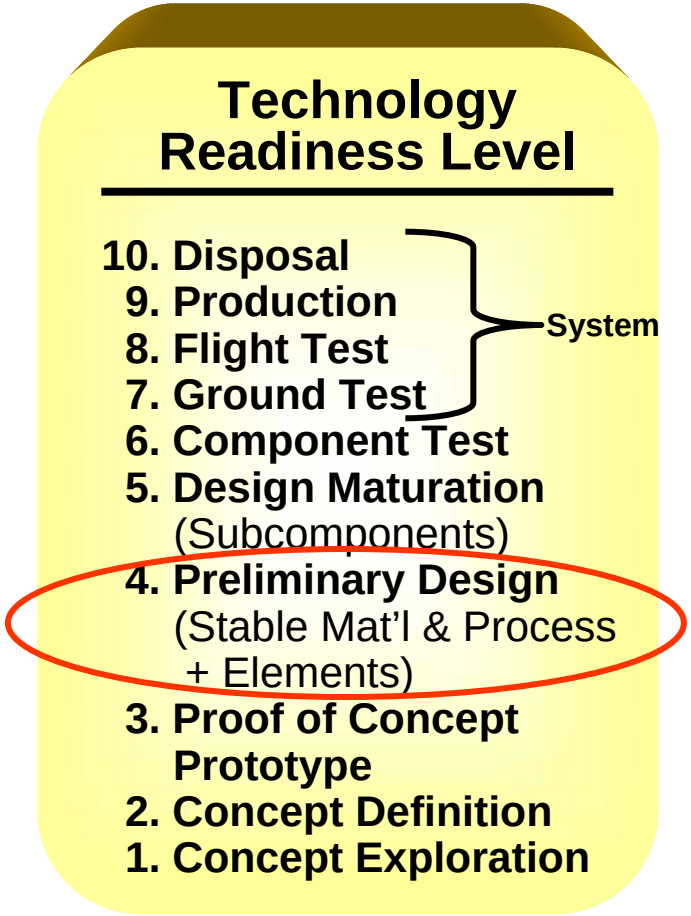
- Observables
- EMI/Lightning Strike
- Supplier Base
- Applications History
- Certification Agency & Status
  - USN
  - USAF
  - ARMY
  - FAA

Risk in Each Area is Dependent Upon Application's Criticality and Material's Likelihood of Failure

Maturity

Technology Readiness Level (TRL) For Maturity

Designer Perspective



PROS

- Looks at maturity from a designer/system viewpoint
- Broken down into specific activity areas
- Is geared towards application products and systems for readiness

CONS

- Does not take into account different discipline perspectives
- Does not address detailed areas/items at each readiness level

Based on NASA, Air Force and ONR Technology Maturity Level Approaches

Maturity

Readiness Levels From a Technologist Viewpoint

Technologist Perspectives

Readiness Level
9. Industry Std
8. Production
7. Qualified Mat'l/Process/Mfg
6. Pre-Production
5. Pilot Production
4. Lab/Prototype Production
3. Beaker/Bench Product
2. Theoretical/Beaker Product
1. Concept Exploration

PROS

- Looks at maturity from a technologist viewpoint
- Broken down into specific activity areas
- Is geared towards materials, processing and manufacturing for readiness

CONS

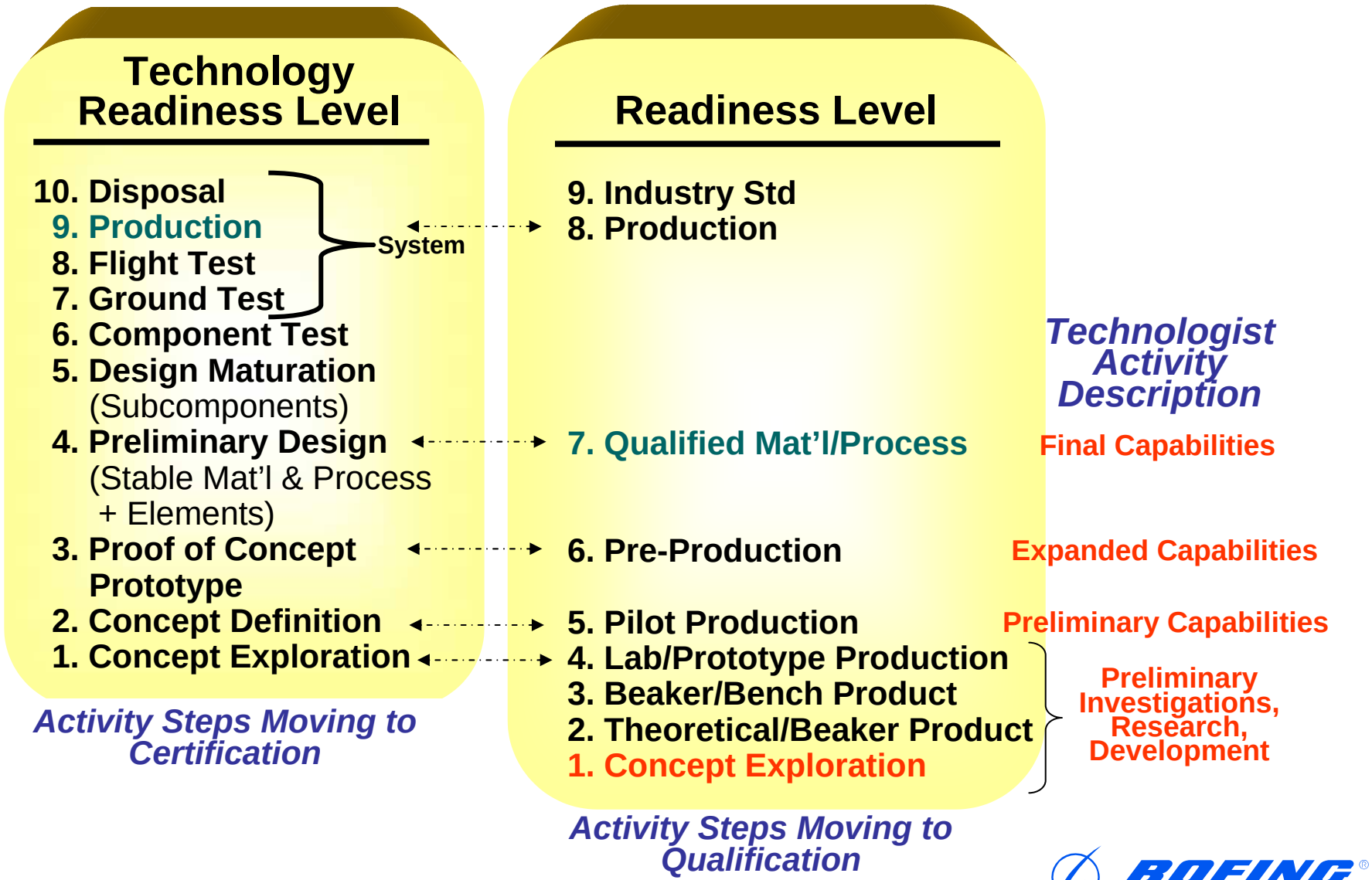
- Is not tied/connected to TRL's from the system or application viewpoint
- Does not take into account different discipline perspectives
- Does not address detailed areas/items at each readiness level

Maturity

- **Certification**
  - Application Requirements/Needs Demonstrated
  - Stepwise Risk Reduction (Building Block Approach)
  - Performance Characteristics for Primary/Secondary/ Air Loaded Structures
- **Qualification**
  - Materials and Processing are Stable
  - Material and Processing Specifications
- **Transition**
  - Customer Acceptance for an Application or Applications

Maturity

Connections/Correlations for Readiness Levels



Multiple Disciplines

TRL	0	1	2	3	4	5	6	7	8	9	10
Certification	Qualification Plan Assessment	Certification Elements Documented	Certification Plan Documented	Certification Plan Approved	Elements	Subcomponent Testing	Full Scale Component Testing	Full Scale Airframe Tests	Flight Test	Production Approval	Disposal Plan Approval
Application/ Design	Technology Readiness Review	System Requirements Review	Project Planning Review	Preliminary Design Review	Critical Design Review	Full Scale Test Readiness Review	Ground Test Certification Review	Flight Test Certification Review	Production Readiness Review	Production Support	Recycle or Dispose
Assembly/ Quality	Preliminary Assembly Concept Assessed	Assembly Concept	Assembly Plan Definition	Key Assembly Detail Definitions	Key Assembly Details Tested	Subcomponents Assembled	Components Assembled	Airframe Assembled	Flight Vehicles Assembled	Production	Disassembly for Disposal
Survivability	General Requirements Assessed	Requirements Definition	Concept Definition	Proof of Concept	Preliminary Design Data and Guidelines	Design Allowables and Guidelines Defined	Critical Details Testing	Ground Test	Flight Test	Production Support	Operations Support & Disposal
Fabrication/ Quality	Fabrication Capability Demonstrated	Unfeatured-Panel Fabrication	Feature Based Generic Small/Subscale Parts Fabricated	Property-Fab Relationships Tested/ Target Application Pilot Production of Generic Full Size Parts	Process Specs/ Effects of Fab Variations Tested/ Elements Fab'd/ Production Representative Parts Fab'd	Subcomponents Fab'd	Full Scale Components Fabricated	EMD Fabrication	Low Rate Initial Production (LRIP)	Production	Recycle or Disposal
Supportability	Repair Requirements Assessed	Repair Items/Areas Identified	Repair Materials & Processes Identified	Repair Materials & Processes Documented	Fab Repairs Identified	Fab Repair Trials/ Subcomponent Repairs	Component Repairs	Production Repairs Identified	Flight Qualified Repairs Documented	Repair-Replace Decisions	Support for Recycle or Disposal Decisions
Structures & Durability	Preliminary Properties-Characteristics Assessed	Preliminary Properties-Characteristics	Initial Properties	Design To Properties Developed	Preliminary Design Allowables	Final Design Allowables	Allowables for Critical Design Features	Production and Test Support	Certified Allowables	Flight Tracking/ Production Support/ Fleet Support	Retirement for Cause
Materials	Lab-Prototype Materials	Lab-Prototype Materials Reproducibile	Pilot Production Materials	Pre-Production Materials	Production Sacleability Validated	EMD Material Supplied	EMD Material Supplied	EMD Material Supplied	LRIP Material Supplied	Production Material Supplied	Support for Recycle or Disposal Decisions
Cost/Schedule/ Benefits	Cost Benefit Elements ID'd & Assessed	Cost Benefit Elements ID'd & Projected	ROM Cost Benefit Analysis	Cost Benefit Analysis Reflect Size Lessons Learned	Cost Benefit Analysis Reflect Element and Production Representative Part Lessons Learned	Cost Benefit Analysis Reflect Subcomponent Fab & Assembly Lessons Learned	Cost Benefit Analysis Reflect Component Fab & Assembly Lessons Learned	Cost Benefit Analysis Reflect EMD Lessons Learned	Cost Benefit Analysis Reflect LRIP Lessons Learned	Cost Benefit Analysis Reflect Production Lessons Learned	Cost Benefit Analysis Reflect Disposal Lessons Learned
Intellectual Rights	Concept Protection Plan Developed	Protection Plan Documentation	Patent Disclosure Filed	Proprietary Rights Agreements	Data Sharing Rights	Vendor Agreements	Material and Fabrication Contracts	Production Rate Contracts	Vendor Requal Agreements	Post-Production Agreements	Liability Termination Agreements

…Multiple Disciplines Have Different Perspectives for Technical Maturity Level Exit Criteria

Multiple Disciplines

Structures and Durability Breakout

Exit Criteria Vary According to Application

- In-plane Ultimate Strength -- Unnotched Compression
- In-plane Ultimate Strength -- Unnotched Tension
- Ultimate Strength -- Combined Loads
- In-plane Ultimate Strength -- Open Hole Compression
- In-plane Ultimate Strength -- Open Hole Tension
- Ultimate Strength -- Open Hole, Combined Loads
- Stability - Global/Panel
- Stability - Skin Buckling
- Stability - Stringer Crippling
- Stability - Stringer Column Buckling
- Bond/Interlaminar Joint Strength - Damage Initiation
- Bond/Interlaminar Joint Strength - Final Failure
- Bolted Joint - Bearing/Bypass
- Maximum Deflection
- Residual Strength -- BVID, Compression
- Residual Strength -- Penetrations, Tension
- Residual Strength -- Penetrations, Compression
- Residual Strength -- Penetrations, Combined Loads
- Local Stability - Face wrinkling (Sandwich Only)
- Local Stability - Intracell Buckling (Sandwich Only)
- Local Stability - Shear Crimping (Sandwich Only)

Exit Criteria Tends to Vary According to OEM and Customer

- Durability/Life - Microcracking
- Durability/Life - Delamination Growth
- Durability/Life - Stiffness Degradation
- Durability/Life - Bearing Strength Degradation
- Material Mechanical Properties - Primary (Tension, Compression, Shear, Bearing By-pass)
- Material Mechanical Properties - Secondary (CTE, Poisson's, Fracture Toughness,)
- Material Mechanical Properties - Other ()
- Material Durability/Life Properties - Environmental Impact on Properties
- Material Durability/Life Properties - Impact Resistance and Fatigue
- Material Durability/Life Properties - Solvent Resistance

Multiple Disciplines

Materials, Processing and Producibility Breakout With Example Exit Criteria

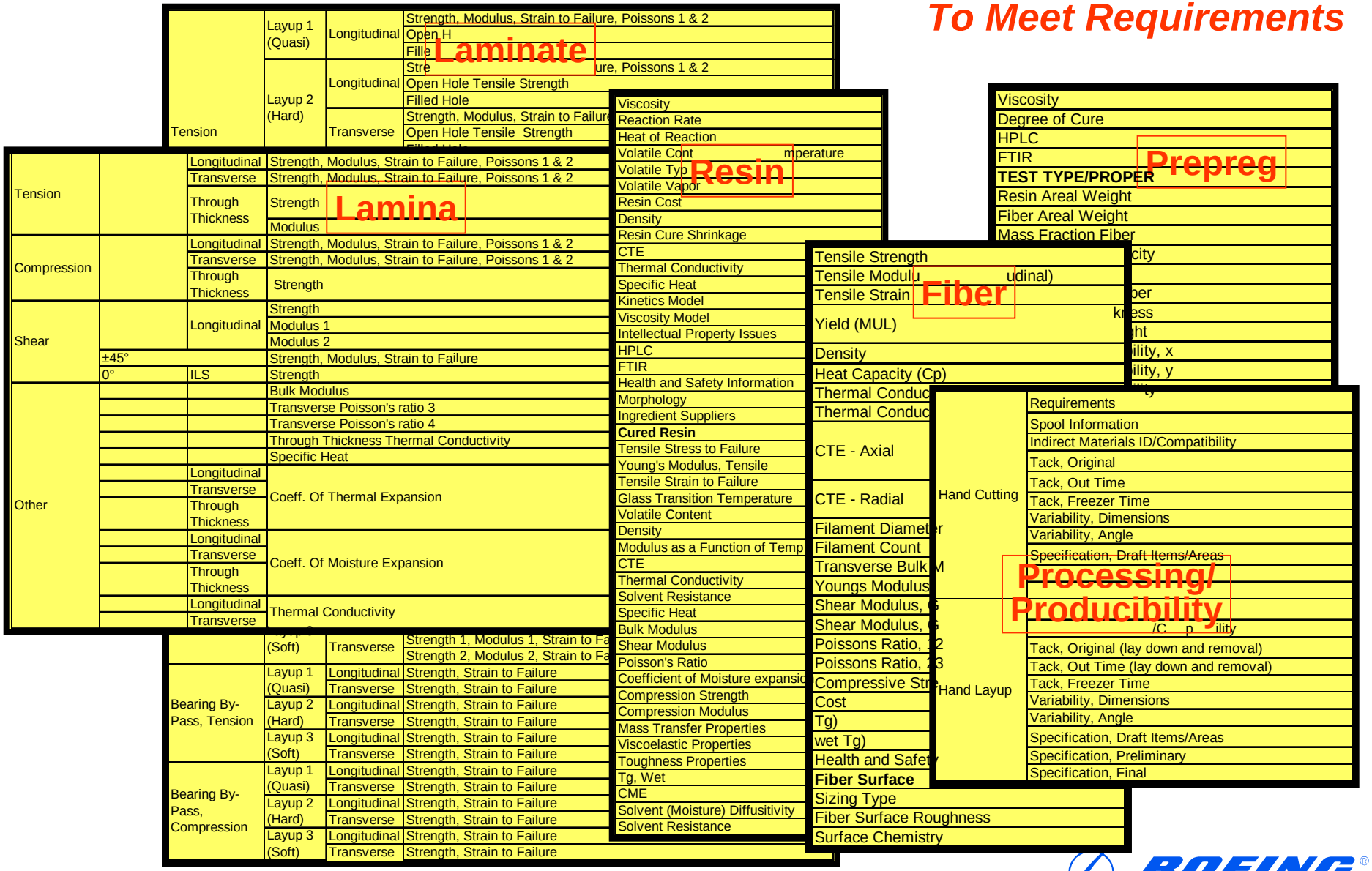
MATERIAL	Critical functions/ characteristics of material/ ingredients demonstrated. New material within state-of-the-art. Indirect material requirements identified. Facility requirements identified.
PROCESSES	Critical functions/ characteristics of processing demonstrated. New process operates within state-of-the-art. Facility requirements identified. Indirect materials or process steps identified.
EQUIPMENT	Critical functions/ characteristics of individual equipment pieces demonstrated. Indirect materials and facility requirements identified. Equipment accuracy requirements defined.
TOOLING	Critical functions/ characteristics of individual tooling pieces demonstrated. Indirect materials and facility requirements identified. Tooling accuracy requirements defined.
VARIABILITY	Variabilities roughly characterized.

QUALITY - IN-PROCESS	Critical quality functions/characteristics demonstrated. Indirect material and/or process steps identified. Facility requirements identified. Defects identified
QUALITY - FINAL PRODUCT	Critical quality functions/characteristics demonstrated. Indirect material and/or process steps identified. Facility requirements identified. Defects identified.
APPLICATION MATURITY	Critical functions/characteristics demonstrated; physical phenomena understood.
COST/BENEFIT ANALYSIS	Key costs/benfits have had a preliminary assessment for quantification.
SUPPORTABILITY	Critical repair functions and characteristics demonstrated.
REGULATORY	Regulatory issues understood.
Intellectual Property	Reduction to practice in progress. Strategy to issue patents or preserve technology as trade secret accepted.

- **Combines Both Objective and Subjective Areas**
  - Includes Property and Characteristic Measurements
  - Includes Production Readiness Assessments
- **Each Individual Material and Processing/ Producibility Step Needs to be Addressed**

Conformance

…….Varies According to Application, Maturity, Discipline and Customer To Meet Requirements



Summary

- **Multiple Discipline Perspective Integrates Requirements and Conformance to Requirements**
- **Multiple Discipline Conformance Activities Covers The Spectrum of All Areas and Items for Material Insertion**
- **Certification and Qualification is Very Complex**
- **Primary Emphasis is Risk Reduction Relative to Applications**

Ending

"The best information on a new material are the first things heard about it. It only goes downhill from there."

Quote Attributed to Flake Campbell Jr.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